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# Plant Community Composition and Structure Monitoring for Agate Fossil Beds National Monument, 2016 Data Report

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Natural Resource Stewardship and Science

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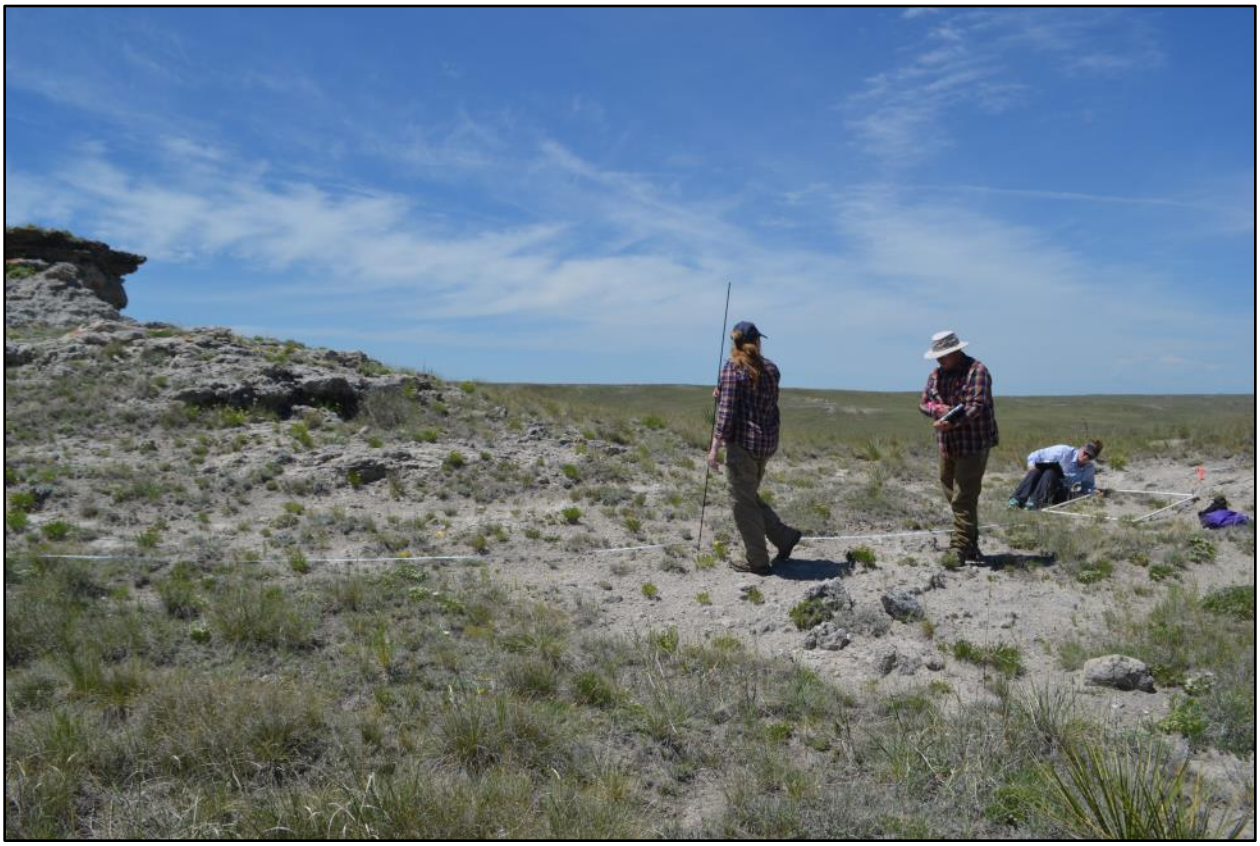
*2016 Data Report*

Natural Resource Data Series NPS/NGPN/NRDS—2016/1074



**ON THIS PAGE**
Plant Community Composition and Structure Monitoring plot PCM-026 at Agate Fossil Beds National Monument, June 2016.
Crew members collecting transect data pictured from right to left: Logan LaFleur, Joe Ladd, and Kristyn Rugg
Photograph courtesy of the National Park Service.

**ON THE COVER**
Plant Community Composition and Structure Monitoring plot PCM-015 at Agate Fossil Beds National Monument, June 2016.
Photograph courtesy of the National Park Service.

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U.S. Department of the Interior
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# Abstract

This report presents the results of vegetation monitoring efforts in 2016 at Agate Fossil Beds National Monument (AGFO) by the Northern Great Plains Inventory and Monitoring Network (NGPN).

During the sixth full year of field work, crew members from NGPN visited six long-term plant community monitoring (PCM) plots and the Northern Great Plains Fire Effects Crew (NGPFire) visited nine fire plant community monitoring (FPCM) plots to collect data on the plant communities at AGFO. This effort is part of a long-term monitoring program established to better understand the condition of the mixed-grass prairie, riparian, and upland regions in AGFO. NGPN staff collected species richness, herb-layer height, native and exotic (non-native) species abundance, ground cover, and site disturbance data at six PCM plots. The NGPFire crew collected species richness and native and exotic species cover data at each of the nine FPCM plots. An additional seventeen riparian community monitoring (RCM) plots were also evaluated for species richness and cover of native and exotic species.

Our 2016 findings can be summarized as follows: Monitoring crews identified 92 plant species in fifteen combined plots (six PCM plus nine FPCM) visited in 2016 at AGFO and twelve of these species were exotic. None of the exotic species identified in upland plots were on the target list for the early detection and rapid response program in the Northern Great Plains Network parks. Ten rare native species were also identified. The most common disturbances observed in monitoring plots were prescribed fire and animal use. In riparian monitoring plots, 80 plant species were identified, of which 17 species were exotic in this area. One exotic species identified in the RCM plots, pale yellow iris (*Iris pseudacorus*), is on the target list for the early detection and rapid response program. That invasive exotic species was identified in eleven out of the seventeen RCM plots. Eight rare native species were identified in thirteen RCM plots.

## Acknowledgments

We thank the authors of the NGPN Plant Community Monitoring Protocol, particularly A. Symstad, for outstanding guidance on data collection and reporting. Thank you to the staff at AGFO for providing logistical support and safety checks. The 2016 NGPN vegetation field crew of C. Davis, S. Rockwood, W. Vogel, and M. Davis, with the assistance of the Northern Great Plains Fire Effects crew of D. Swanson, E. Watson, I. Muirhead, and C. Tomford, collected all the data included in this report.

# Introduction

Agate Fossil Beds National Monument was established in 1965 to protect and preserve a large concentration of ancient mammal fossils. The monument contains 2,270 acres of mixed-grass prairie intersected by riparian vegetation along the Niobrara River. Vegetation monitoring began in AGFO in 1998 by the Heartland Inventory & Monitoring Program (James 2010a) and the Northern Great Plains Fire Ecology Program (FireEP; Wienk et al. 2011). In 2010, AGFO was incorporated into the Northern Great Plains Inventory & Monitoring Network (NGPN). At this time, vegetation monitoring protocols and plot locations were revised to better represent the entire monument and to coordinate efforts with the FireEP (Symstad et al. 2012b), and sampling efforts began in 2011 (Ashton et al. 2011). In 2012, the NGPN began monitoring an additional 12 plots within the riparian corridor of the Niobrara River system to assess riparian condition. Three riparian plots were added in 2014, and an additional 5 RCM plots were added in 2015, for a total number of 20 RCM plots in the park.

In this report, we provide summaries of the data collected at fifteen upland plots (six plant community plots and nine fire effects plots) as well as a summary of the17 riparian plot data collected in 2016. Please refer to the "Northern Great Plains Fire Ecology Annual Report: Calendar Year 2016" and the Agate Fossil Beds National Monument River North Fire Effects Monitoring Report for park burn unit analysis and interpretation of the 2016 monitoring results accessible on the Data Store https://irma.nps.gov/DataStore.

# Methods

The NGPN Plant Community Composition and Structure Monitoring Protocol (Symstad et al. 2012b, a) describes in detail the methods used for sampling long-term plots. Below, we briefly describe the general approach. For those interested in more detail, please see the protocol publications cited above, and available at http://science.nature.nps.gov/im/units/ngpn/monitor/plants.cfm.

### NGPN Monitoring Plots 2016

The NGPN and NGPFire implemented a survey to monitor plant community structure and composition in AGFO using a spatially balanced probability design (Generalized Random Tessellation Stratified [GRTS]; Stevens and Olsen 2003, 2004). Using a GRTS design, NGPN selected 16 randomly located sites within the upland grasslands of AGFO to install Plant Community Monitoring (PCM) plots. The NGPN usually surveys 2 panels (in AGFO, 6 PCM plots) every year using a rotating sampling scheme where one panel (three sites in AGFO) was visited in the previous year and the other panel (three sites in AGFO) was most recently visited four years previous (Figure 1). After a full five-year rotation, ideally, each plot will have been visited twice. When a PCM plot was located within an active burn unit, NGPFire added additional visits based on a preburn, 1, 2, 5, and 10 year post-burn sampling schedule using the same GRTS sampling schema. In 2016, the NGPN crew visited PCM plots in panel 1 and panel 5 (Table 1) and the NGPFire crew visited nine plant community monitoring plots including both PCM and fire plant community monitoring

(FPCM) plots from May 25th through June 8th. NGPFire collects post-burn severity data at PCM plots in addition to FPCM plots when PCM plots are within the extent of a prescribed fire.

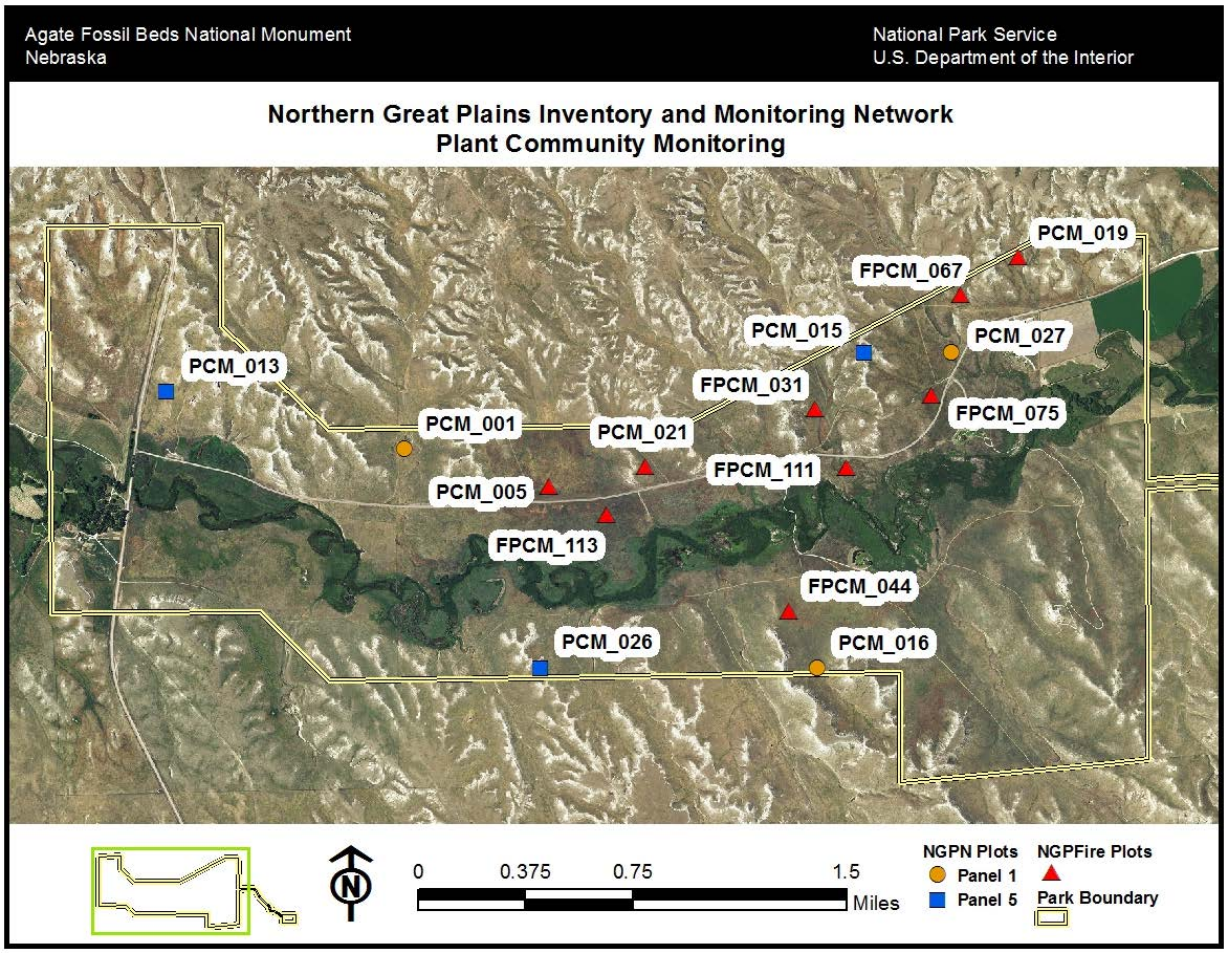


**Figure 1.** Map of Agate Fossil Beds National Monument (AGFO) plant community monitoring plots visited in 2016. Fifteen long-term plots were monitored in 2016: three Panel 1 plots (orange circles), three Panel 5 plots (blue squares) and nine NGPFire plot visits, which include both FPCM and PCM plots (red triangles). NGPFire collects post-burn severity and vegetative cover data at PCM plots in addition to FPCM plots when PCM plots are within the extent of a prescribed fire.

**Table 1.** Field journal for Northern Great Plains I&M Network plant community monitoring in Agate Fossil Beds National Monument (AGFO) in the 2016 season. Plant community monitoring was completed with a crew of four to five people. On May 25, 2016, half the crew worked at Scotts Bluff National Monument (SCBL) to monitor a final plot, while the remaining crew traveled to AGFO from SCBL to monitor two plots before returning to Rapid City.

| Date | Travel Time (hrs) | Housing | Plots Read | Plot Notes (time needed, etc.) |
|---|---|---|---|---|
| Wednesday May 25, 2016 | 3 | N/A | AGFO_PCM_013 | 5 crew, X hrs |
| | | | AGFO_PCM_027 | 5 crew, 1.75 hrs |
| Monday June 6, 2016 | 3 | Park Housing | AGFO_PCM_001 | 4 crew, 2.3 hrs |
| Tuesday June 7, 2016 | N/A | Park Housing | AGFO_PCM_016 | 4 crew, 3 hrs |
| | | | AGFO_PCM_026 | 4 crew, 1.75 hrs |
| Wednesday June 8, 2016 | N/A | Park Housing | AGFO_PCM_026 | 4 crew, 4 hrs |
| | 3 | N/A | AGFO_PCM_015 | 4 crew, 2.25 hrs |
| Tuesday August 23, 2016 | 3 | Park Housing | AGFO_RCM_258 | 5 crew, 2 hrs |
| Wednesday August 24, 2016 | N/A | Park Housing | AGFO_RCM_257, 259, 260, 261, 262, 264, 265, 266, 267, 268, 269, 270, | 5 crew, 10.25 hrs |
| Thursday August 25, 2016 | 3 | N/A | AGFO_RCM_263, 271, 272, 273 | 5 crew, 6 hrs |

**Table 2.** Plant community monitoring by NGPFire in Agate Fossil Beds National Monument (AGFO) for the 2016 season. Plant community monitoring was completed using a crew of three people. The 228 acre River North prescribed fire was completed on April 8, 2016. Post-burn severity monitoring on three plots within the unit were completed immediately following the burn. * 2016 Northern Great Plains Fire Ecology Annual Report and AGFO River North Fire Effects Monitoring Report contain detailed information on changes to vegetative composition and cover following prescribed fire as well as fire objectives, progression, weather, behavior, smoke, and plot analysis.

| Date | Plots Read | Burn Unit | Monitoring Status * |
|---|---|---|---|
| April 8, 2016 | AGFO_PCM_005 | River North | Immediate Post-burn |
| April 8, 2016 | AGFO_PCM_021 | River North | Immediate Post-burn |
| April 8, 2016 | AGFO_FPCM_031 | River North | Immediate Post-burn |
| June 1, 2016 | AGFO_PCM_021 | River North | Year 1 post-burn |
| June 1, 2016 | AGFO_PCM_031 | River North | Year 1 post-burn |
| June 2, 2016 | AGFO_PCM_005 | River North | Year 1 post-burn |
| May 31, 2016 | AGFO_PCM_019 | North Carnegie | Preburn |
| May 31, 2016 | AGFO_FPCM_067 | North Carnegie | Preburn |
| June 1, 2016 | AGFO_FPCM_075 | North Carnegie | Preburn |
| June 1, 2016 | AGFO_FPCM_111 | North Carnegie | Preburn |
| June 1, 2016 | AGFO_FPCM_113 | River Middle | Year 2 post-burn |
| June 1, 2016 | AGFO_FPCM_044 | River South | Year 2 post-burn |

## Plot Layout and Sampling

At each of the PCM plots visited, the NGPN crew documented plant species cover and frequency in a rectangular, 50 m x 20 m (0.1 ha), permanent plot (Figure 2). Data on ground cover, herb-layer height ≤ 2 m, and plant cover were collected along two 50 m transects (the long sides of the plot) using a point-intercept method. At 50 locations along each transect, once every 1 meter, a pole was dropped to the ground and all species that touched the pole were recorded, along with ground cover and canopy height. Species richness data from the point-intercept method were supplemented with species presence data collected in five 1 $m^2$ quadrats located systematically along each transect (Figure 2). Only point-intercept data were collected during FPCM plot visits.

All six PCM plots were located in upland mixed-grass prairie devoid of trees, and as a result, no tree, seedling, or woody fuel data were collected in AGFO plots visited in 2016.

Disturbances and target early detection exotic species were also assessed and documented at each PCM plot. Common disturbances included fire and animal use, primarily small animal burrows and animal trails. For all plots, the type, severity, and approximate area ($m^2$) of the disturbances were recorded. Early detection exotic species have the potential to spread into the park and cause significant ecological impacts were chosen in collaboration with the Midwest Invasive Plant Network, the Exotic Plant Management Team, park managers, and local weed experts (Table 2). For each early detection exotic species present, an abundance class was given on a scale from 1-5 where 1 = one individual, 2 = few individuals, 3 = cover of 1-5%, 4 = cover of 5-25%, and 5 = cover > 25% of the plot. The information gathered from this procedure is critical for early detection and rapid response to such threats. No disturbance or early-detection data were collected at FPCM plots.

NGPN also monitored riparian plant communities in AGFO in August of 2016 in riparian plant community monitoring (RCM) plots. At RCM plots, vegetation was measured using the point-intercept method as described above, along a single 50 m transect that ran perpendicular to the river channel. These plots are not permanently marked and are relocated using GPS coordinates.

The conservation status ranks of plant species in Nebraska are determined by the Nebraska Natural Heritage Program (NENHP) and for the purpose of this report, a species was considered rare if its conservation status rank was S1, S2, or S3. See Table 3 for a detailed definition of each conservation status rank.

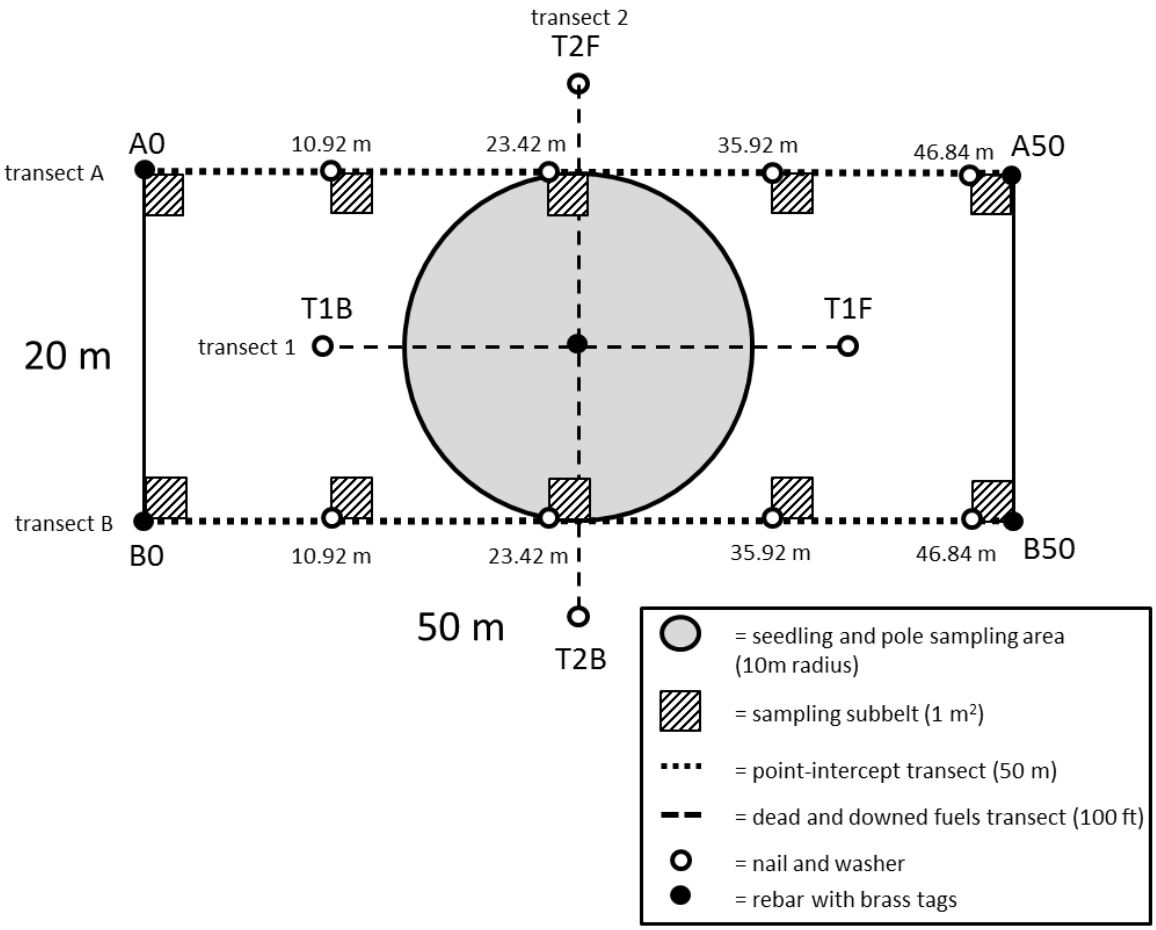


**Figure 2.** Long-term monitoring plot layout used for sampling vegetation in Agate Fossil Beds National Monument.

**Table 3.** Northern Great Plains Network early detection and rapid response exotic species. NGPN monitoring crews searched for these exotic species at Agate Fossil Beds National Monument at each plot.

| Scientific Name | Common Name | Habitat |
|---|---|---|
| *Alliaria petiolata* | garlic mustard | Riparian |
| *Polygonum cuspidatum; P. sachalinense; P. x bohemicum* | knotweeds | Riparian |
| *Pueraria montana* var. *lobata* | kudzu | Riparian |
| *Iris pseudacorus* | yellow iris | Riparian |
| *Ailanthus altissima* | tree of heaven | Riparian |
| *Lepidium latifolium* | perennial pepperweed | Riparian |
| *Arundo donax* | giant reed | Riparian |
| *Rhamnus cathartica* | common buckthorn | Riparian |
| *Heracleum mantegazzianum* | giant hogweed | Riparian |
| *Centaurea solstitialis* | yellow star thistle | Upland |
| *Hieracium aurantiacum; H. caespitosum* | orange and meadow hawkweed | Upland |
| *Isatis tinctoria* | Dyer's woad | Upland |

| Scientific Name | Common Name | Habitat |
|---|---|---|
| *Taeniatherum caput-medusae* | medusahead | Upland |
| *Chondrilla juncea* | rush skeletonweed | Upland |
| *Gypsophila paniculata* | baby's breath | Upland |
| *Centaurea virgata; C.diffusa* | knapweeds | Upland |
| *Linaria dalmatica; L. vulgaris* | toadflax | Upland |
| *Euphorbia myrsinites & E. cyparissias* | myrtle spurge | Upland |
| *Dipsacus fullonum & D. laciniatus* | common teasel | Upland |
| *Salvia aethiopis* | Mediterranean sage | Upland |
| *Ventenata dubia* | African wiregrass | Upland |

**Table 4.** Definitions of state and global species conservation status ranks*.

| Status Rank | Category | Definition |
|---|---|---|
| **S1/G1** | Critically imperiled | Due to extreme rarity (5 or fewer occurrences) or other factor(s) making it especially vulnerable to extirpation. |
| **S2/G2** | Imperiled | Due to rarity resulting from a very restricted range, very few populations (often 20 or fewer), steep declines, or other factors making it very vulnerable to extirpation. |
| **S3/G3** | Vulnerable | Due to a restricted range, relatively few populations (often 80 or fewer), recent widespread declines, or other factors making it vulnerable to extirpation. |
| **S4/G4** | Apparently secure | Uncommon but not rare; some cause for concern due to declines or other factors. |
| **S5/G5** | Secure | Common, widespread and abundant. |
| **S#S#/ G#G#** | Range rank (e.g. S2S3) | Used to indicate uncertainty about the status of the species or community. Ranges cannot skip more than one rank. |

*Adapted from NatureServe status assessment table (http://www.natureserve.org/conservation-tools/conservation-status-assessment)

## Data Management and Analysis

The FFI database (FEAT/FIREMON Integrated; http://frames.gov/ffi/) was used as the primary software environment for managing the sampling data. This database is used by a variety of agencies (e.g., NPS, USDA Forest Service, U.S. Fish and Wildlife Service), has a national-level support system, and generally conforms to the Natural Resource Database Template standards established by the Inventory and Monitoring Program. Species scientific names, codes, and common names are from the USDA Plants Database (USDA-NRCS 2016). Nomenclature follows the Integrated Taxonomic Information System (ITIS) standards (http://www.itis.gov). In the rare case where ITIS recognized a new name that was not in the USDA Plants database, the new name was used and a unique plant code was assigned. After data for the sites were entered into the FFI database, 100% of database records were verified with the original data sheets to minimize transcription errors, followed by a final 10% check. After all data were entered and verified, automated queries were used to check for errors in the data. When errors were identified by the crew or the automated queries, changes were made to the original datasheets and the FFI database as needed.

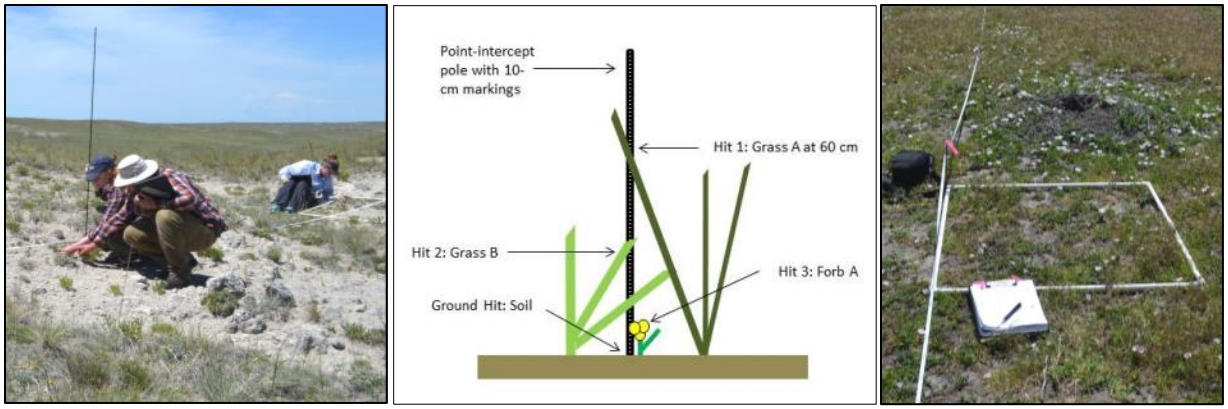


**Figure 3.** The Northern Great Plains Inventory & Monitoring vegetation crew used point-intercept at PCM_026 (left and center panel) and 1m$^2$ quadrats (right panel) to document plant diversity and abundance.

# Results

## Plant Community Monitoring

There are a total of 453 plant species on the AGFO species list (https://irma.nps.gov/NPSpecies/Search/SpeciesList/AGFO). Monitoring crews identified 92 of these species in fifteen monitoring plots visited in the spring of 2016 (Table 4). Of these plant species, 12 of are exotic species at AGFO. All exotics identified were either forbs or graminoids.

We observed the greatest native species diversity at AGFO_PCM_015, where 41 native species were identified (Table 5). Plots AGFO_PCM_026 and AGFO_FPCM_067 had the greatest absolute native species cover (Table 6). The greatest exotic species absolute cover was observed in plot AGFO_FPCM_027 with 90% cheatgrass cover (Table 6).

Ten plant species observed in 2016 are classified as rare in Nebraska. Two species identified are critically imperiled: hairy false goldenaster (*Heterotheca villosa*) and nodding buckwheat *(Eriogonum cernuum)*; three species are considered imperiled: western tansymustard (*Descurainia pinnata*), buff fleabane (*Erigeron ochroleucus*), and woolly plantain *(Plantago patagonica)*; and four species are considered vulnerable: winterfat (*Krascheninnikovia lanata*), largeflower Townsend daisy (*Townsendia grandiflora*), stiffstem flax (*Linum rigidum*), and purple threeawn (*Aristida purpurea*). (Table 4)

There were no live trees or seedlings present in monitoring plots visited in 2016.

**Table 5.** List of all plant species identified in AGFO long-term plant community monitoring plots in 2016. The species are grouped by plant family. An "X" in the exotic column means that species is not native to the park or, in the case where only the genus was identified, there are some species within that genus that are exotic. Species considered to be rare in Nebraska are marked in the final column and the state conservation ranks are provided. Conservation rank definitions are in Table 3 of this report.

| Family | Code | Scientific Name | Common Name | Exotic | Rare |
|---|---|---|---|---|---|
| Agavaceae | YUGL | *Yucca glauca* | soapweed yucca | | |
| Apiaceae | CYGL99 | *Cymopterus glomeratus* | plains springparsley | | |
| | MUTE3 | *Musineon tenuifolium* | slender wildparsley | | |
| Asteraceae | AMPS | *Ambrosia psilostachya* | Cuman ragweed | | |
| | ARFR4 | *Artemisia frigida* | prairie sagewort | | |
| | CICA11 | *Cirsium canescens* | prairie thistle | | |
| | COCA5 | *Conyza canadensis* | Canadian horseweed | | |
| | ERBE2 | *Erigeron bellidiastrum* | western daisy fleabane | | |
| | EROC | *Erigeron ochroleucus* | buff fleabane | | |
| | GUSA2 | *Gutierrezia sarothrae* | broom snakeweed | | |
| | HELIA3 | *Helianthus* spp. | sunflower | | |
| | HEVI4 | *Heterotheca villosa* | hairy false goldenaster | | S1 |
| | LASE | *Lactuca serriola* | prickly lettuce | X | |
| | LIPU | *Liatris punctata* | dotted blazing star | | |
| | LYJU | *Lygodesmia juncea* | rush skeletonplant | | |
| | MUOB99 | *Mulgedium oblongifolium* | blue lettuce | | |
| | PACA15 | *Packera cana* | woolly groundsel | | |
| | SOCA6 | *Solidago canadensis* | Canada goldenrod | | S3S5 |
| | SOMI2 | *Solidago missouriensis* | Missouri goldenrod | | |
| | SYER | *Symphyotrichum ericoides* | white heath aster | | S3S5 |
| | SYMPH4 | *Symphyotrichum* spp. | aster | | |
| | TEAC | *Tetraneuris acaulis* | stemless four-nerve daisy | | |
| | TOGR | *Townsendia grandiflora* | largeflower Townsend daisy | | S3S5 |
| | TRDU | *Tragopogon dubius* | yellow salsify | X | |

**Table 5 (continued).** List of all plant species identified in AGFO long-term plant community monitoring plots in 2016. The species are grouped by plant family. An "X" in the exotic column means that species is not native to the park or, in the case where only the genus was identified, there are some species within that genus that are exotic. Species considered to be rare in Nebraska are marked in the final column and the state conservation ranks are provided. Conservation rank definitions are in Table 3 of this report.

| Family | Code | Scientific Name | Common Name | Exotic | Rare |
|---|---|---|---|---|---|
| Boraginaceae | CRCA8 | *Cryptantha cana* | mountain cryptantha | | |
| | LAOC3 | *Lappula occidentalis* | flatspine stickseed | | |
| | LIIN2 | *Lithospermum incisum* | narrowleaf stoneseed | | |
| Brassicaceae | CAMI2 | *Camelina microcarpa* | littlepod false flax | X | |
| | DEPI | *Descurainia pinnata* | western tansymustard | | S3S5 |
| | DESO2 | *Descurainia sophia* | herb sophia | X | |
| | ERCA14 | *Erysimum capitatum* | sanddune wallflower | | |
| | LEDE | *Lepidium densiflorum* | common pepperweed | | |
| | PHLU99 | *Physaria ludoviciana* | foothill bladderpod | | |
| | SIAL2 | *Sisymbrium altissimum* | tall tumblemustard | X | |
| Cactaceae | OPFR | *Opuntia fragilis* | brittle pricklypear | | |
| | OPPO | *Opuntia polyacantha* | plains pricklypear | | |
| Caryophyllaceae | ERHO13 | *Eremogone hookeri* | Hooker's sandwort | | |
| | PADE4 | *Paronychia depressa* | spreading nailwort | | |
| Chenopodiaceae | CHENO | *Chenopodium* spp. | goosefoot | X | |
| | KRLA2 | *Krascheninnikovia lanata* | winterfat | | |
| | SATR12 | *Salsola tragus* | prickly Russian thistle | X | |
| Commelinaceae | TROC | *Tradescantia occidentalis* | prairie spiderwort | | |
| Cyperaceae | CAFI | *Carex filifolia* | threadleaf sedge | | |
| Euphorbiaceae | CRTE4 | *Croton texensis* | Texas croton | | |
| | EUBR | *Euphorbia brachycera* | horned spurge | | |
| Fabaceae | ASSP6 | *Astragalus spatulatus* | tufted milkvetch | | |
| | DACA7 | *Dalea candida* | white prairie clover | | |
| | LAPO2 | *Lathyrus polymorphus* | manystem pea | | |

**Table 5 (continued).** List of all plant species identified in AGFO long-term plant community monitoring plots in 2016. The species are grouped by plant family. An "X" in the exotic column means that species is not native to the park or, in the case where only the genus was identified, there are some species within that genus that are exotic. Species considered to be rare in Nebraska are marked in the final column and the state conservation ranks are provided. Conservation rank definitions are in Table 3 of this report.

| Family | Code | Scientific Name | Common Name | Exotic | Rare |
|---|---|---|---|---|---|
| Fabaceae (continued) | LUPL | *Lupinus plattensis* | Nebraska lupine | | |
| | MEOF | *Melilotus officinalis* | yellow sweetclover | X | |
| | PSLA3 | *Psoralidium lanceolatum* | lemon scurfpea | | |
| | PSTE5 | *Psoralidium tenuiflorum* | slimflower scurfpea | | |
| Hydrophyllaceae | ELNY | *Ellisia nyctelea* | Aunt Lucy | | |
| Lamiaceae | HEHI | *Hedeoma hispida* | rough false pennyroyal | | |
| Liliaceae | ALTE | *Allium textile* | textile onion | | |
| Linaceae | LIRI | *Linum rigidum* | stiffstem flax | | S3S5 |
| Loasaceae | MEDE2 | *Mentzelia decapetala* | tenpetal blazingstar | | |
| Malvaceae | SPCO | *Sphaeralcea coccinea* | scarlet globemallow | | |
| Melanthiaceae | TOVE2 | *Toxicoscordion venenosum* | meadow deathcamas | | |
| Onagraceae | OEAL | *Oenothera albicaulis* | whitest evening-primrose | | |
| | OESE3 | *Oenothera serrulata* | yellow sundrops | | |
| | OESU99 | *Oenothera suffrutescens* | scarlet beeblossom | | |
| Orobanchaceae | ORFA | *Orobanche fasciculata* | clustered broomrape | | |
| Plantaginaceae | PLPA2 | *Plantago patagonica* | woolly plantain | | |
| Poaceae | ACHY | *Achnatherum hymenoides* | Indian ricegrass | | |
| | ARPU9 | *Aristida purpurea* | purple threeawn | | S3S5 |
| | BOGR2 | *Bouteloua gracilis* | blue grama | | |
| | BRJA | *Bromus japonicus* | Japanese brome | X | |
| | BRTE | *Bromus tectorum* | cheatgrass | X | |
| | CALO | *Calamovilfa longifolia* | prairie sandreed | | |
| | ELEL5 | *Elymus elymoides* | squirreltail | | |
| | ELTR7 | *Elymus trachycaulus* | slender wheatgrass | | |

**Table 5 (continued).** List of all plant species identified in AGFO long-term plant community monitoring plots in 2016. The species are grouped by plant family. An "X" in the exotic column means that species is not native to the park or, in the case where only the genus was identified, there are some species within that genus that are exotic. Species considered to be rare in Nebraska are marked in the final column and the state conservation ranks are provided. Conservation rank definitions are in Table 3 of this report.

| Family | Code | Scientific Name | Common Name | Exotic | Rare |
|---|---|---|---|---|---|
| Poaceae (continued) | HECO26 | *Hesperostipa comata* | needle and thread | | |
| | MUCU3 | *Muhlenbergia cuspidata* | plains muhly | | |
| | MUPA99 | *Muhlenbergia paniculata* | tumblegrass | | |
| | PASM | *Pascopyrum smithii* | western wheatgrass | | |
| | POPR | *Poa pratensis* | Kentucky bluegrass | X | |
| | SCSC | *Schizachyrium scoparium* | little bluestem | | |
| | SPCR | *Sporobolus cryptandrus* | sand dropseed | | |
| | VUOC | *Vulpia octoflora* | sixweeks fescue | | |
| Polemoniaceae | PHAN4 | *Phlox andicola* | prairie phlox | | |
| | PHHO | *Phlox hoodii* | spiny phlox | | |
| Polygonaceae | ERAN4 | *Eriogonum annuum* | annual buckwheat | | |
| | ERCE2 | *Eriogonum cernuum* | nodding buckwheat | | |
| | ERFL4 | *Eriogonum flavum* | alpine golden buckwheat | | |
| | RUVE2 | *Rumex venosus* | veiny dock | | |
| Santalaceae | COUM | *Comandra umbellata* | bastard toadflax | | |
| Scrophulariaceae | CASE5 | *Castilleja sessiliflora* | downy paintedcup | | |
| | PEAN4 | *Penstemon angustifolius* | broadbeard beardtongue | | |
| Solanaceae | PHHI8 | *Physalis hispida* | prairie groundcherry | | |
| Unknown family | UNKFORB | Unknown forb | unknown forb | X | |
| Violaceae | VINU2 | *Viola nuttallii* | Nuttall's violet | | |

**Table 6 .** Number of plant species per plot identified in each plot surveyed at Agate Fossil Beds National Monument in 2016. (* Plot data only include point-intercept species data, and as a result, fewer species observed)

| MacroPlot Name | Native | Exotic | Total |
|---|---|---|---|
| AGFO_PCM_015 | 41 | 3 | 44 |
| AGFO_PCM_026 | 38 | 4 | 42 |
| AGFO_PCM_001 | 23 | 5 | 28 |
| AGFO_PCM_016 | 22 | 6 | 28 |
| AGFO_PCM_013 | 17 | 8 | 25 |
| AGFO_PCM_027 | 17 | 10 | 27 |
| AGFO_FPCM_067 * | 12 | 2 | 14 |
| AGFO_PCM_021 * | 10 | 1 | 11 |
| AGFO_FPCM_113 * | 10 | 4 | 14 |
| AGFO_PCM_019 * | 7 | 2 | 9 |
| AGFO_FPCM_075 * | 7 | 1 | 8 |
| AGFO_PCM_005 * | 5 | 2 | 7 |
| AGFO_FPCM_111 * | 4 | 4 | 8 |

**Table 7.** Absolute and relative cover of native and exotic species in plots monitored at Agate Fossil Beds National Monument in 2016. Absolute cover includes overlapping species canopies and can be greater than 100%. (* NGPN Fire Effects plot visits)

| Macro Plot Name | Absolute Cover (%) | | Relative Cover (%) | |
|---|---|---|---|---|
| | Native | Exotic | Native | Exotic |
| AGFO_FPCM_067 * | 119 | 20 | 86 | 14 |
| AGFO_PCM_026 | 119 | 1 | 99 | 1 |
| AGFO_PCM_016 | 102 | 38 | 73 | 27 |
| AGFO_PCM_019 * | 101 | 46 | 69 | 31 |
| AGFO_PCM_027 | 99 | 84 | 54 | 46 |
| AGFO_PCM_001 | 96 | 9 | 91 | 9 |
| AGFO_PCM_013 | 96 | 2 | 98 | 2 |
| AGFO_PCM_021 * | 81 | 2 | 98 | 2 |
| AGFO_PCM_015 | 78 | 0 | 100 | 0 |
| AGFO_FPCM_113 * | 77 | 19 | 80 | 20 |
| AGFO_FPCM_031 | 71 | 1 | 99 | 1 |
| AGFO_FPCM_044 | 70 | 90 | 44 | 56 |
| AGFO_FPCM_111 * | 52 | 60 | 46 | 54 |
| AGFO_FPCM_075 * | 48 | 71 | 40 | 60 |
| AGFO_PCM_005 * | 35 | 49 | 42 | 58 |

Disturbances were observed in all PCM plots in 2016 (Table 7). The most common disturbance types were animal use; primarily small mammal burrows (not including prairie dogs, *Cynomys ludovicianus*), and fire signs of previous year prescribed fires which was observed as char and scars on resilient vegetation (i.e. *Yucca glauca*). Evidence of fire was recorded in three of the six plots in 2016: PCM_001, PCM_015, and PCM_026. These plots were all located within the extent of prescribed burns from previous years (see Table 7 for approximate area of disturbance).

**Table 8.** Disturbance type and approximate area observed in six plots visited at Agate Fossil Beds National Monument in 2016. Extent was estimated in $m^2$ of a total area of 1000 $m^2$.

| MacroPlot Name | Disturbance Type | Size ($m^2$) |
|---|---|---|
| AGFO_PCM_001 | Small Mammal | 500 |
| | Rx Fire | 1000 |
| AGFO_PCM_013 | Small Mammal | 60 |
| AGFO_PCM_015 | Small Mammal | 3 |
| | Rx Fire | 660 |
| AGFO_PCM_016 | Small Mammal | 400 |
| AGFO_PCM_026 | Small Mammal | 7 |
| | Rx Fire | 20 |
| AGFO_PCM_027 | Small Mammal | 40 |

## Riparian Plant Community Monitoring

In addition to upland plant community plots, 17 riparian community monitoring plots were visited in 2016 (Figure 4). Riparian plots are monitored every year and the total number of plots visited is typically dictated by time constraints. The RCM plots were visited in the last week of August and evaluated for species richness and abundance of native and exotic species.

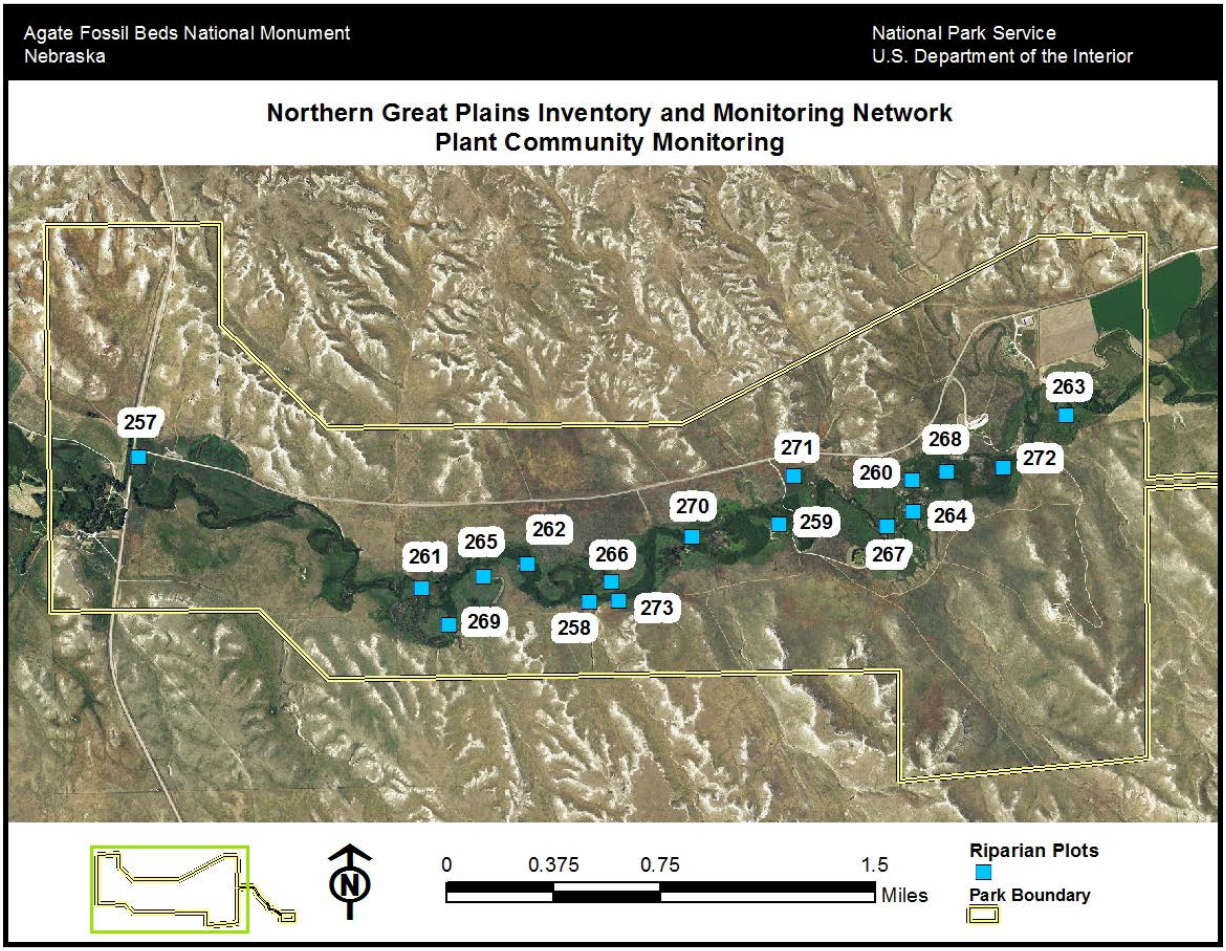


**Figure 4.** Map of Agate Fossil Beds National Monument (AGFO) riparian community monitoring plots visited in 2016. Twenty long-term plots were established by NGPN and the Fire Effects Program (NGPFire) between 2011 and 2015. Seventeen of the twenty RCM plots were surveyed in 2016.

The NGPN monitoring crew identified 80 species in seventeen RCM plots in 2016 (Table 8). Of these plant species, 17 are exotic in AGFO and these exotic plants were either forbs or graminoids. AGFO_RCM_269, a plot in the central southwest section of the park, was the most diverse plot with 19 unique native plant species. AGFO_RCM_269 had the highest native species cover. AGFO_RCM_265, located roughly at the center of the park, had the greatest exotic species cover which was primarily composed of Kentucky bluegrass (Table 8). Pale yellow iris *(Iris pseudacorus)*, an early detection exotic species, was identified in 10 of the 17 RCM plots monitored in 2016.

**Table 9.** List of all plant species identified in AGFO riparian plant community monitoring plots in 2016. The species are grouped by plant family. An "X" in the exotic column means that species is not native to the park or, in the case where only the genus was identified, there are some species within that genus that are exotic. Species considered to be rare in Nebraska are marked in the final column and the state conservation ranks provided.

| Family | Code | Scientific Name | Common Name | Exotic | Rare |
|---|---|---|---|---|---|
| Alismataceae | SACU | *Sagittaria cuneata* | arumleaf arrowhead | | |
| Apiaceae | CIMA2 | *Cicuta maculata* | spotted water hemlock | | S3S5 |
| Asclepiadaceae | ASIN | *Asclepias incarnata* | swamp milkweed | | |
| | ASSP | *Asclepias speciosa* | showy milkweed | | |
| Asteraceae | AMPS | *Ambrosia psilostachya* | Cuman ragweed | | |
| | ARFR4 | *Artemisia frigida* | prairie sagewort | | |
| | BICE | *Bidens cernua* | nodding beggartick | | |
| | BIFR | *Bidens frondosa* | devil's beggartick | | |
| | CIAR4 | *Cirsium arvense* | Canada thistle | X | |
| | CIFL | *Cirsium flodmanii* | Flodman's thistle | | |
| | COCA5 | *Conyza canadensis* | Canadian horseweed | | |
| | CYXA | *Cyclachaena xanthifolia* | giant sumpweed | | |
| | HEAN3 | *Helianthus annuus* | common sunflower | | |
| | HELIA3 | *Helianthus* | sunflower | X | |
| | LASE | *Lactuca serriola* | prickly lettuce | X | |
| | MUOB99 | *Mulgedium oblongifolium* | blue lettuce | | |
| | SOAR2 | *Sonchus arvensis* | field sowthistle | X | |
| | SOCA6 | *Solidago canadensis* | Canada goldenrod | | S3S5 |
| | SOGI | *Solidago gigantea* | giant goldenrod | | |
| | SOLID | *Solidago* | goldenrod | | |
| | SYLA6 | *Symphyotrichum lanceolatum* | white panicle aster | | |
| | TRDU | *Tragopogon dubius* | yellow salsify | X | |
| Brassicaceae | DESO2 | *Descurainia sophia* | herb sophia | X | |
| Caprifoliaceae | SYOC | *Symphoricarpos occidentalis* | western snowberry | | |

**Table 9 (continued).** List of all plant species identified in AGFO riparian plant community monitoring plots in 2016. The species are grouped by plant family. An "X" in the exotic column means that species is not native to the park or, in the case where only the genus was identified, there are some species within that genus that are exotic. Species considered to be rare in Nebraska are marked in the final column and the state conservation ranks provided.

| Family | Code | Scientific Name | Common Name | Exotic | Rare |
|---|---|---|---|---|---|
| Chenopodiaceae | ATMI2 | *Atriplex micrantha* | twoscale saltbush | X | |
| | KOSC | *Kochia scoparia* | burningbush, kochia | X | |
| Cleomaceae | PESE99 | *Peritoma serrulata* | Rocky Mountain beeplant | | |
| Cyperaceae | CADU6 | *Carex duriuscula* | needleleaf sedge | | |
| | CAPE42 | *Carex pellita* | woolly sedge | | |
| | CAPR5 | *Carex praegracilis* | clustered field sedge | | |
| | CAREX | *Carex* | sedge | | |
| | ELER | *Eleocharis erythropoda* | bald spikerush | | |
| | SCPU10 | *Schoenoplectus pungens* | common threesquare | | |
| | SCTA2 | *Schoenoplectus tabernaemontani* | softstem bulrush | | |
| Equisetaceae | EQAR | *Equisetum arvense* | field horsetail | | |
| | EQLA | *Equisetum laevigatum* | smooth horsetail | | |
| Fabaceae | GLLE3 | *Glycyrrhiza lepidota* | American licorice | | |
| | MEOF | *Melilotus officinalis* | yellow sweetclover | X | |
| Iridaceae | IRPS | *Iris pseudacorus* | paleyellow iris | X | |
| Juncaceae | JUBA | *Juncus balticus* | Baltic rush | | |
| Lamiaceae | LYAM | *Lycopus americanus* | American water horehound | | |
| | LYAS | *Lycopus asper* | rough bugleweed | | |
| | MEAR4 | *Mentha arvensis* | wild mint | | |
| | SCLA2 | *Scutellaria lateriflora* | blue skullcap | | |
| Lemnaceae | LEMI3 | *Lemna minor* | common duckweed | | S3S5 |
| Lentibulariaceae | UTRIC | *Utricularia* | bladderwort | | |
| Onagraceae | EPCI | *Epilobium ciliatum* | fringed willowherb | | |
| | EPLE2 | *Epilobium leptophyllum* | bog willowherb | | |

**Table 9 (continued).** List of all plant species identified in AGFO riparian plant community monitoring plots in 2016. The species are grouped by plant family. An "X" in the exotic column means that species is not native to the park or, in the case where only the genus was identified, there are some species within that genus that are exotic. Species considered to be rare in Nebraska are marked in the final column and the state conservation ranks provided.

| Family | Code | Scientific Name | Common Name | Exotic | Rare |
|---|---|---|---|---|---|
| Poaceae | AGGI2 | *Agrostis gigantea* | redtop | X | |
| | BRJA | *Bromus japonicus* | Japanese brome | X | |
| | CALO | *Calamovilfa longifolia* | prairie sandreed | | |
| | DISP | *Distichlis spicata* | saltgrass | | |
| | ELEL5 | *Elymus elymoides* | squirreltail | | |
| | ELRE4 | *Elymus repens* | quackgrass | X | |
| | ELTR7 | *Elymus trachycaulus* | slender wheatgrass | | S1 |
| | HOJU | *Hordeum jubatum* | foxtail barley | | |
| | LEOR | *Leersia oryzoides* | rice cutgrass | | |
| | MUAS | *Muhlenbergia asperifolia* | scratchgrass | | |
| | MURA | *Muhlenbergia racemosa* | marsh muhly | | |
| | PACA6 | *Panicum capillare* | witchgrass | | S3S5 |
| | PASM | *Pascopyrum smithii* | western wheatgrass | | |
| | PAVI2 | *Panicum virgatum* | switchgrass | | |
| | POPR | *Poa pratensis* | Kentucky bluegrass | X | |
| | SPGR | *Spartina gracilis* | alkali cordgrass | | |
| | SPOB | *Sphenopholis obtusata* | prairie wedgescale | | S2S4 |
| | SPPE | *Spartina pectinata* | prairie cordgrass | | |
| Polygonaceae | PEAM8 | *Persicaria amphibia* | longroot smartweed | | S3S5 |
| | RUMEX | *Rumex* | dock | X | |
| Potamogetonaceae | POTAM | *Potamogeton* | pondweed | | |
| Rubiaceae | GATI | *Galium tinctorium* | stiff marsh bedstraw | | |
| Salicaceae | SAER | *Salix eriocephala* | Missouri River willow | | S3S5 |
| | SAIN3 | *Salix interior* | sandbar willow | | |
| | SALIX | *Salix* | willow | | |

**Table 9 (continued).** List of all plant species identified in AGFO riparian plant community monitoring plots in 2016. The species are grouped by plant family. An “X” in the exotic column means that species is not native to the park or, in the case where only the genus was identified, there are some species within that genus that are exotic. Species considered to be rare in Nebraska are marked in the final column and the state conservation ranks provided.

| Family | Code | Scientific Name | Common Name | Exotic | Rare |
|---|---|---|---|---|---|
| Scrophulariaceae | VEAN2 | *Veronica anagallis-aquatica* | water speedwell | | |
| Solanaceae | PHHI8 | *Physalis hispida* | prairie groundcherry | | |
| Typhaceae | TYAN | *Typha angustifolia* | narrowleaf cattail | | |
| | TYLA | *Typha latifolia* | broadleaf cattail | | |
| Unknown family | UNKFORB | *Unknown forb* | unknown forb | X | |
| | UNKGRAM | *Unknown graminoid* | unknown graminoid | X | |
| Urticaceae | URDI | *Urtica dioica* | stinging nettle | | |
| Alismataceae | SACU | *Sagittaria cuneata* | arumleaf arrowhead | | |

**Table 10.** Number of plant species per plot identified in each riparian monitoring plot at Agate Fossil Beds National Monument in 2016.

| Macro Plot Name | Native | Exotic | Total |
|---|---|---|---|
| AGFO_RCM_269 | 19 | 4 | 23 |
| AGFO_RCM_258 | 17 | 4 | 21 |
| AGFO_RCM_267 | 17 | 5 | 22 |
| AGFO_RCM_261 | 16 | 4 | 20 |
| AGFO_RCM_270 | 15 | 4 | 19 |
| AGFO_RCM_262 | 14 | 1 | 15 |
| AGFO_RCM_264 | 13 | 6 | 19 |
| AGFO_RCM_273 | 12 | 3 | 15 |
| AGFO_RCM_260 | 11 | 3 | 14 |
| AGFO_RCM_272 | 11 | 1 | 12 |
| AGFO_RCM_259 | 10 | 1 | 11 |
| AGFO_RCM_263 | 10 | 3 | 13 |
| AGFO_RCM_266 | 10 | 2 | 12 |
| AGFO_RCM_268 | 9 | 2 | 11 |
| AGFO_RCM_257 | 7 | 1 | 8 |
| AGFO_RCM_265 | 7 | 6 | 13 |
| AGFO_RCM_271 | 3 | 3 | 6 |

**Table 11.** Absolute and relative cover of native and exotic species in riparian plots monitored at Agate Fossil Beds National Monument in 2016. Absolute cover includes overlapping species canopies and can be greater than 100%.

| Macro Plot Name | Absolute Cover (%) | | Relative Cover (%) | |
|---|---|---|---|---|
| | Native | Exotic | Native | Exotic |
| AGFO_RCM_269 | 242 | 52 | 82 | 18 |
| AGFO_RCM_266 | 180 | 56 | 76 | 24 |
| AGFO_RCM_261 | 174 | 30 | 85 | 15 |
| AGFO_RCM_264 | 158 | 100 | 61 | 39 |
| AGFO_RCM_265 | 156 | 108 | 59 | 41 |
| AGFO_RCM_258 | 150 | 42 | 78 | 22 |
| AGFO_RCM_260 | 136 | 88 | 61 | 39 |
| AGFO_RCM_262 | 126 | 60 | 68 | 32 |
| AGFO_RCM_263 | 120 | 42 | 74 | 26 |
| AGFO_RCM_267 | 120 | 72 | 63 | 38 |
| AGFO_RCM_259 | 96 | 58 | 62 | 38 |
| AGFO_RCM_270 | 96 | 54 | 64 | 36 |
| AGFO_RCM_272 | 92 | 62 | 60 | 40 |
| AGFO_RCM_271 | 84 | 34 | 71 | 29 |
| AGFO_RCM_273 | 82 | 54 | 60 | 40 |
| AGFO_RCM_257 | 74 | 2 | 97 | 3 |
| AGFO_RCM_268 | 52 | 42 | 55 | 45 |

Eight plant species identified in the RCM plots are rare in Nebraska. One species is critically imperiled: slender wheatgrass (*Elymus trachycaulus*), one species is considered imperiled: prairie wedgescale (*Sphenopholis obtusata*), and six species are considered vulnerable: spotted water hemlock (*Cicuta maculata*), Canada goldenrod (*Solidago canadensis*), common duckweed (*Lemna minor*), witchgrass (*Panicum capillare*), longroot smartweed (*Persicaria amphibia*), and Missouri River willow (*Salix eriocephala*) (Table 8).

**Figure 5.** View from the Niobrara River at AGFO_RCM_ 258 facing north.

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